PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-023724
(43)Date of publication of application : 23.01.1998

(51)Int.Cl. H02K 29/06
H02K 1/14
H02K 11/00
H02P 5/41
H02P 7/63

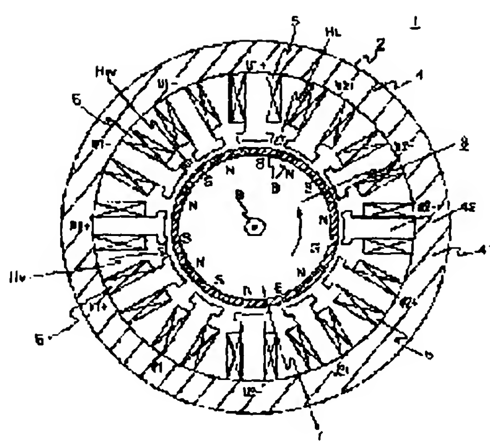
(21)Application number : 08-173403
(22)Date of filing : 03.07.1996

(71)Applicant : HITACHI LTD
JAPAN SERVO CO LTD

(72)Inventor : TAJIMA FUMIO
KAWAMATA SHOICHI
MATSUNOBU YUTAKA
ABUKAWA TOSHIMI
ONISHI KAZUO

(54) PERMANENT-MAGNET ROTARY ELECTRIC MACHINE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a permanent-magnet rotary electric machine which is reduced in pulsative torque and has a small size and light weight by setting the arranging intervals of adjacently arranged magnetic pole position detectors for different phases at a specific multiple of the arranging width of one stator magnetic poles.
SOLUTION: The arranging intervals of magnetic pole position detectors Hu, Hv, and Hw are set double the arranging width of one stator magnetic pole 42. In other words, the detectors Hu, Hv, and Hw are arranged at intervals which are equal to the arranging width of two stator magnetic poles 42. That is, the detectors Hu, Hv, and Hw receive influences form the stator magnetic poles 32 and the magnetic field formed by winding currents at the same (equivalent) level. Consequently, the electric angle of 60$0 between the magnetic poles 42 do not deflect to 50° or 70°, but the accuracy of magnetic pole position signals can be secured and the increase of pulsative torques can be suppressed. Therefore, the interval between each detector Hu, Hv, and Hw becomes shorter and the size and weight of a permanent-magnet rotary electric machine can be reduced.



LEGAL STATUS

[Date of request for examination] 17.11.1999
[Date of sending the examiner's decision of rejection] 23.10.2001
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The stator which has the stator winding of the polyphase intensively wound around M stator magnetic poles. P permanent magnet poles magnetized mostly at equal intervals. It is the permanent magnet rotation electrical machinery equipped with the above, and the arrangement interval of each adjacent aforementioned phase magnetic pole position transducer is characterized by being set as the double precision of the position interval of the aforementioned stator magnetic pole for one piece.
[Claim 2] The aforementioned stator winding starts from U phase in a claim 1. U phase in order of U1+, U1-, U2-, and U2+ It is the permanent magnet rotation electrical machinery which W phase places the aforementioned stator magnetic pole for one piece from U1+, and is characterized by for V phase having placed the aforementioned stator magnetic pole for one more piece in order of W1-, W1+, W2+, and W2-, and connecting all in this direction in order of V1+, V1-, V2-, and V2+.
[Claim 3] The stator which has the stator winding of the three phase circuit intensively wound around M stator magnetic poles. The permanent magnet pole of P pole magnetized mostly at equal intervals. It is the permanent magnet rotation electrical machinery equipped with the above, and is characterized by having placed the stator magnetic pole for one piece for the stator winding wound around the aforementioned stator magnetic pole with U phase as the starting point, having placed W phase and the stator magnetic pole for one more piece, and connecting in the same direction in order of V phase.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to permanent magnet rotation electrical machinery, and relates to the permanent magnet rotation electrical machinery which has the small small lightweight concentrated-winding stator of torque throb especially.
[0002]
[Description of the Prior Art] The concentration volume permanent magnet rotation electrical machinery of composition of a small permanent-magnetic motor having a stator magnetic pole generally, and arranging a stator winding intensively to the magnetic pole of a parenthesis has been used. since the section serves as simple composition until now as opposed to the distributed-winding stator currently used to the field of a large-sized rotating machine, the physique of a motor can be made small, and the number of coils can be lessened -- since -- there is an advantage, like composition becomes simple With this kind of permanent magnet rotation electrical machinery, it was general to have set the ratio of the pole P of the permanent magnet of permanent magnet rotation electrical machinery and the number M of magnetic poles of a stator to 2:3. However, the above-mentioned method had a fault with large cogging torque.
[0003] on the other hand -- JP,62-110468,A (henceforth the example 1 of an indication) -- the pole P of a permanent magnet, and several magnetic poles of a stator -- about the permanent magnet rotation electrical machinery which set M to P:M=6n**2:6n (however, n two or more integers), reduction of cogging torque and the utilization factor of a coil improve, and it is indicating that a small motor with little throb torque can be offered for an electric airframe rank
[0004] On the other hand, in JP,62-221854,A (example 2 of a henceforth, indication), the example which has arranged mechanically arrangement of a magnetic pole position transducer (it is used in the case of [three] a three phase circuit) required for making this kind of brushless motor operate at the interval of 120 degrees is indicated. It is the composition which arranges the electrical angle of the magnetic pole position transducer of each phase at the interval of 120 degrees so that all can operate the magnetic pole position of three pieces as a brushless motor.
[0005]
[Problem(s) to be Solved by the Invention] In order to make a brushless motor into the low thing of small lightweight one and ripple factor torque, it is required for a relation with the stator winding by which the position of three magnetic pole position transducers was wound around near, the magnetic pole position transducer of each phase they are [phase] three pieces and a stator magnetic pole, and its circumference to be the same.
[0006] However, the above-mentioned example 2 of an indication has the fault which the position of a magnetic pole position transducer leaves distantly. Moreover, a relation with the stator winding which the magnetic pole position transducer of each phase separated 120 electrical angles at a time, and was wound around the magnetic pole position transducer of each phase, a stator magnetic pole, and its circumference in the shortest position There was a fault which changes [(for example, the magnetic pole position transducer of V phase is also arranged under the stator magnetic pole around which the stator winding of U phase is wound to the magnetic pole position transducer of U phase being arranged under the stator magnetic pole around which the stator winding of U phase is wound), and]. This was because the precision of a magnetic pole position transducer makes it differ greatly by each interphase and makes big throb torque produce by this.
[0007] Moreover, for the example 1 of an indication, the wiring composition between each salient pole magnetic pole is devised, and it is not indicated about the small technology tied up lightweight.
[0008] Therefore, the purpose of this invention solves the technical problem of the above-mentioned example of an indication, and is to offer offering small lightweight permanent magnet rotation electrical machinery and small lightweight permanent magnet rotation electrical machinery with still smaller and throb torque.
[0009]
[Means for Solving the Problem] The feature of the permanent magnet rotation electrical machinery by this invention which attains the above-mentioned purpose The stator which has the stator winding of the polyphase intensively wound around M stator magnetic poles, It has the rotator which has P permanent magnet poles magnetized mostly at equal intervals. The permanent magnet pole P and the number M of stator magnetic poles And P:M=6n**2:6n (however n detect the magnetic pole position of the aforementioned rotator with the magnetic pole position transducer of each phase from the magnetic flux which two or more relations of integer), nothing, and the aforementioned permanent magnet pole make. According to this detection magnetic pole position, the arrangement interval of each aforementioned phase magnetic pole position transducer with which the energization control to each aforementioned phase stator winding adjoins each other in the permanent magnet rotation electrical machinery made and driven is in the composition set as the double precision of the position interval of the aforementioned stator magnetic pole for one piece.
[0010] Moreover, the stator which has the stator winding of the three phase circuit which wound other features around M stator magnetic poles intensively, In the permanent magnet rotation electrical machinery which was equipped with the rotator which has the permanent magnet pole of P pole magnetized mostly at equal intervals, and considered the permanent magnet pole P and the number M of stator magnetic poles as the P:M=6n**2:6n (however, n two or more integers) relation It is in the point which placed the stator magnetic pole for one piece for the stator winding wound around the aforementioned stator magnetic pole with U phase as the starting point, placed W phase and the stator magnetic pole for one more piece, and was connected in the same direction in order of V phase.

[0011] According to this invention, the magnetic pole position transducer of each phase can perform magnetic pole position detection in the position influenced [same] by the magnetic pole and coil of a stator while being arranged by the electrical angle of 120 degrees, respectively. Magnetic pole position detection becomes exact and the interval between each magnetic pole position transducer can make throb torque small by it while it becomes the shortest and small lightweight-ization is attained by this.
[0012] Moreover, each phase becomes the same and the connection length of a stator winding can tie it up lightweight small.
[0013]
[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing. Drawing 1 is the cross section showing the permanent magnet rotation electrical machinery of one example by this invention. The cross-section structure of the permanent magnet rotation electrical machinery in connection with this invention is shown. Drawing 2 is drawing showing AA cross section of drawing 1 . Composition is explained simultaneously with reference to drawing 1 and drawing 2 .
[0014] In drawing 1 , the permanent magnet rotation electrical machinery 1 (henceforth the rotation electrical machinery 1) consists of a stator 2, a rotator 3, the end bracket 10, two bearings 11, three magnetic pole position transducers (Hu, Hv, Hw), and wiring substrates Pt. A stator 2 consists of housing 9, a stator core 4 fixed to the inner skin of this housing 9, and a stator winding 5 of the polyphase wound around this stator core 4. A rotator 3 consists of a permanent magnet 6, a yoke 7, and a shaft 8. Moreover, a shaft 8 is held free [rotation] to a stator 2 with bearing 11, housing 9, and the end bracket 10. And in order to detect the position of the permanent magnet 6 of a rotator 3, the wiring substrate Pt arranged in the interior of the rotation electrical machinery 1 is equipped with the magnetic pole position transducer which generally consists of hall devices etc.
[0015] In drawing 2 , the rotation electrical machinery 1 mainly consists of a stator 2 and a rotator 3, and a stator 2 consists of a stator core 4 and a stator winding 5. Here, a stator core 4 is the composition that consist of a stator yoke 41 in a circle and two or more stator magnetic poles 42, and a stator winding 5 is intensively wound around each stator magnetic pole 42. Each coil is the composition which is not things of sharing the magnetic path in an opening side. Since the stator of this concentrated-winding structure can shorten the length of the coil section as opposed to the stator of the distributed-winding structure currently used for the common large-sized machine, it has the advantage which can make the physique of rotation electrical machinery small. With the rotation electrical machinery of this example, the permanent magnet pole of a rotator 3 showed the composition whose number of stator magnetic poles of a stator 2 is 12 pieces by the three phase circuit at 14 pieces. In addition, even if rotation electrical machinery is a generator, being made to the same composition is not saying.
[0016] And corresponding to U1+ as a stator winding 5 of the three phase circuit shown by drawing 2 , U1-, U2+, U2-, V1+, V1- V2+ and V2-, and W1+, W1-, W2+ and W2-, the magnetic pole position transducers Hu, Hv, and Hw of a lot are arranged. Pt is each stator winding 5. While making U1+, U1-, U2+, U2-, V1+, V1-, V2+ and V2-, and W1+, W1-, W2+ and W2- three-phase-connection composition, it is the wiring substrate which fixes and wires the magnetic pole position transducers Hu, Hv, and Hw. Here, the magnetic pole position transducers Hu, Hv, and Hw in this example are aimed at the magnetic pole position transducer of composition of carrying out direct detection of the magnetic pole position of the permanent magnet 6 concerned by the magnetic flux which the permanent magnet 6 of a rotator 3 generates.
[0017] Drawing 3 is drawing showing the permanent magnet rotation electrical machinery control circuit of one example by this invention. The control circuit which drives the permanent magnet rotation electrical machinery shown by drawing 1 is shown. In drawing, the power of DC power supply 12 is supplied to the stator winding 5 of the polyphase of rotation electrical machinery through an inverter 13. Here, an inverter 13 consists of switching elements by the side of the switching element by the side of plus of Tu+, Tv+, and Tw+, and minus of Tu-, Tv-, and Tw-. Furthermore, a magnetic pole position signal is incorporated in a control circuit 14 through the magnetic pole position transducers Hu, Hv, and Hw from the magnetic flux of a rotator 3, and the pulse signal to switching element Tu+ of an inverter 13, Tv+, Tw+, Tu-, Tv-, and Tw- is controlled. Here, the stator winding 5 wound around the stator magnetic pole 42 is connected in order of illustration for every phase using the wiring substrate Pt, respectively, and the connection as rotation electrical machinery 1 of a three phase circuit is made.
[0018] Drawing 4 . It is drawing showing the principle of operation of the permanent magnet rotation electrical machinery by this invention. The inside of drawing, (a), (b), and (c), Magnetic pole position transducers Hu, Hv, and Hw It is a magnetic pole position signal, and this carries out direct detection of the magnetic flux from a rotator 3, and outputs it. It is the signal which Su, Sv, and Sw of (d), (e), and (f) made the above-mentioned magnetic pole position signal the criteria of zero point, and was outputted through the comparator, and Tu, Tv, and Tw signal which are shown by (g), (h), and (i), respectively are added to switching element Tu+ of an inverter 13, Tv+, Tw+, Tu-, Tv-, and Tw-.
[0019] In addition, it is good even if the signal which took the AND (AND) of this Tu and Tv, Tw signal, and a PWM (Pulse Width Modulation) signal is added if needed. That is, by the magnetic flux which the permanent magnet 6 of a rotator 3 makes, the rotation electrical machinery 1 detects the magnetic pole position of the rotator 3 (permanent magnet 6) concerned with the magnetic pole position transducers Hu, Hv, and Hw, and according to this detection magnetic pole position, the energization change control to each stator winding 5 is made, and it drives.
[0020] By the way, it depends for the throb torque of permanent magnet rotation electrical machinery greatly with the precision of the magnetic pole position signal of the magnetic pole position transducers Hu, Hv, and Hw. The signal shown by (g), (h), and (i), respectively is added to switching element Tu+ of an inverter 13, Tv+, Tw+, Tu-, Tv-, and Tw-, and this changes to them like illustration every 60 degrees by the electrical angle. If arrangement of a magnetic pole position transducer is bad and the precision of the aforementioned magnetic pole position signal is bad, the magnetic pole position signal shown by drawing 4 (a), (b), and (c) is confused, for example, in the one section of the inside which is 360 degrees, it will become short with 50 degrees, the section which becomes long with 70 degrees in other sections will be generated, and the throb torque (cogging torque) of the rotation electrical machinery 1 will also become large by this.
[0021] And with the conventional technology, it was that by which the magnetic pole position transducers Hv and Hw are arranged at intervals of 120 degrees on the basis of the magnetic pole position transducer Hu, respectively by the electrical angle (between NS of a permanent magnet is made into 360 degrees). In this case, it means that the magnetic pole position transducers Hv and Hw were arranged in the position of the magnetic pole which wound stator winding U1+ and U1-, respectively. The position of each magnetic pole position transducer Hu, Hv, and Hw of the above-mentioned composition is at each magnetic pole position transducer Hv and Hw to the middle position of the stator magnetic pole 42 with the magnetic pole position transducer Hu. It becomes a position on the stator magnetic pole [position / middle] 42 shifted.
[0022] Moreover, although the magnetic pole position transducer Hu is in the position of the stator winding U phase to control, the magnetic pole position transducers Hv and Hw are in the position of the stator magnetic pole 42 of a different stator winding

U phase from the stator winding V which should be controlled, and W phase. It was the thing to which the influences from the magnetic field which the influence the magnetic pole position transducers Hu, Hv, and Hw are influenced, i.e., the influence from the stator magnetic pole 42, and stator winding current make differ in each with each magnetic pole position transducer, lower the precision of the above-mentioned magnetic pole position signal, and make throb torque increase by these composition.
[0023] In the example by this invention, the arrangement interval which the magnetic pole position transducers Hu, Hv, and Hw adjoin as shown in drawing 2 is set as the double precision of the position interval of the stator magnetic pole 42 for one piece. If it puts in another way, each adjacent phase magnetic pole position transducer has the arrangement interval which consists of a location dimension for two pieces of a stator magnetic pole, and is arranged. According to the composition of the arrangement interval of this example, each magnetic pole position transducers Hu, Hv, and Hw all serve as a middle position (position which has the influence from the magnetic field which the influence and stator winding current from a stator magnetic pole make in an equivalence range) of the stator magnetic pole 42. And in this example, the magnetic pole position transducer Hu has the magnetic pole position transducer Hv in the position which adjoins the stator magnetic pole 42 with a stator winding V phase by being in the position which adjoins the stator magnetic pole 42 which carries out winding maintenance of the stator winding U phase which should be controlled, and the magnetic pole position transducer Hw is arranged as it is in the position of the stator magnetic pole 42 with a stator winding W phase.
[0024] It will be based on the magnetic pole position transducer H1 which adjoined stator winding X1 phase which should be controlled and has been arranged if it furthermore puts in another way. Place the stator magnetic pole for two pieces, adjoin the stator magnetic pole of stator winding X2 phase and this stator winding X2 phase, and the magnetic pole position transducer H2 is arranged. It can be said that the stator magnetic pole for two pieces is placed, the stator magnetic pole of a stator winding Xn phase and this stator winding Xn phase is adjoined one by one, and the magnetic pole position transducer Hn is arranged.
[0025] That is, both the magnetic pole position transducers Hu, Hv, and Hw are influenced of the magnetic field which the influence and coil current of the stator magnetic pole 42 make from the same level (equivalent). 60 electrical angles do not sway with 50 degrees or 70 degrees, the precision of a magnetic pole position signal is secured by this, and the increase in throb torque can be suppressed by it.
[0026] In addition, in arrangement of drawing 2 , the electric interval of the adjacent stator magnetic pole 42 becomes 180 degree x14 pole / 12= 210 degrees. Therefore, they are four pieces (** in drawing, **, **, **) to the magnetic pole position transducer Hu. The magnetic pole position transducer Hv are separated [only from the position of the stator magnetic pole 42] of the position transducer becomes 210 degree x4-720 degree =120 degree, and is arranged in the position in which the phase was 120 degrees. On the other hand, the magnetic pole position transducer Hw it is separated [only from the position of the stator magnetic pole 42 for two pieces] of the position transducer to the magnetic pole position transducer Hu becomes 210 degree x2-360 degree =60 degree. The magnetic pole position transducer Hw can secure the phase contrast of 240 degrees because the magnetic pole position transducer Hw gives the phase contrast of 180 more degrees by reversal of the direction of current, and reversal of a signal to the magnetic pole position transducer Hu in the position of illustration since the phase contrast of 240 degrees is required.
[0027] The concentrated-winding stator which has the stator core equipped with the stator winding of the polyphase which wound the feature of this invention around M stator magnetic poles intensively when summarizing the above, It has the permanent magnet rotator which has P permanent magnet poles magnetized mostly at equal intervals. The permanent magnet pole P and the number M of stator magnetic poles And P:M=6n**2:6n (however n detect the magnetic pole position of the permanent magnet rotator concerned with the magnetic pole position transducer of each phase by the magnetic flux which two or more relations of integer), nothing, and a permanent magnet rotator make. In the permanent magnet rotation electrical machinery made and driven, making the interval of a magnetic pole position transducer into the double precision of the interval of a stator magnetic pole position has the control which changes the energization to the stator winding of each phase wound around the stator magnetic pole according to the detected magnetic pole position.
[0028] By it, the magnetic pole position transducer of each phase can perform magnetic pole position detection in the position where each phase is influenced [same] by the stator magnetic pole etc. while being arranged by this in a position which is different 120 degrees by the electrical angle to a stator magnetic pole and a stator winding, respectively. By this, while the interval of the magnetic pole position transducers of each phase becomes short, the interval changed electrically becomes exact and throb torque becomes small. That is, small, with a bird clapper, the interval of magnetic pole position transducers can attain wiring with a control circuit and a magnetic pole position transducer in the space where the wiring substrate Pt is small, and can connect to small lightweight-ization.
[0029] It starts from U phase of the stator winding 5 wound around the stator magnetic pole 42 on the other hand in the permanent magnet rotation electrical machinery which set the permanent magnet pole P and the number M of stator magnetic poles to P:M=6n**2:6n (however, n two or more integers) as shown in drawing 2 and drawing 3 . In U phase, W phase sets the stator magnetic pole 42 for one piece from U1+ in order of U1+, U1-, U2-, and U2+. In order of W1-, W1+, W2+, and W2- V phase sets the stator magnetic pole 42 for one more piece, and is V1+, V1-, V2-, and V2+. In order, by connecting all in this direction (the inside of drawing circumference of an anti-clock) (wiring) It leads to the drawer position of the coil of U, V, and W phase and the connecting location of the neutral point becoming near, and the connection length of the stator winding of each phase becoming the same, and dispersion in length lessening each phase, and can connect lightweight small. Moreover, a wiring substrate and rotation electrical machinery can also be made small.
[0030] By the above composition, the permanent magnet rotation electrical machinery from which the utilization factor (space efficiency) of wiring between magnetic pole position transducers or a stator winding becomes lightweight it is good and small is offered. Furthermore, the small permanent magnet rotation electrical machinery of throb torque (cogging torque) is offered by raising position detection precision.
[0031] In addition, in this example, although the case where motorised [rotated type] applied was mentioned as the example and explained, this invention is applicable also to the linear motor driving gear as a permanent-magnetic-motor method. Moreover, it cannot be overemphasized that it is applicable also to the method which does not carry out current control, or a 120-degree energization type brushless-motor method further also about the control system which performs sine wave-like control [current] to the position of a rotator.
[0032]
[Effect of the Invention] since according to this invention an electrical angle is made into 120 degrees and each magnetic pole position transducer can be arranged in the position where the influence to each magnetic pole position transducer concerned becomes equivalent, the interval changed electrically is exact -- becoming -- throb torque (cogging torque) -- small -- becoming

-- and the interval of each magnetic pole position transducers -- short -- becoming -- small -- there is an effect connected lightweight Moreover, the coil utilization factor of a stator winding can improve and it can also tie lightweight small.

[Translation done.]

DESCRIPTION OF DRAWINGS

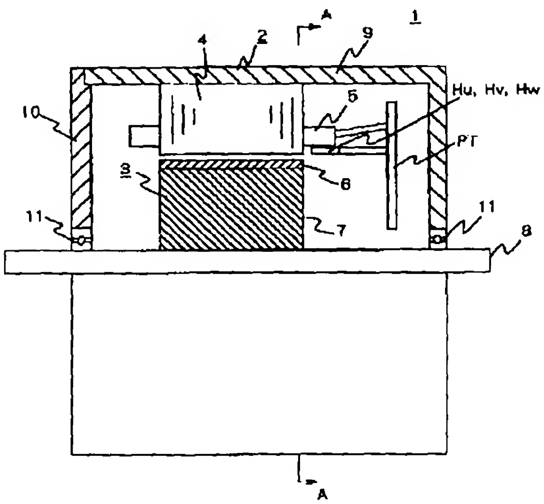
[Brief Description of the Drawings]
[Drawing 1] It is the cross section showing the permanent magnet rotation electrical machinery of one example by this invention.
[Drawing 2] It is drawing showing AA cross section of drawing 1 . The cross section of the permanent magnet rotation electrical machinery of this invention is shown.
[Drawing 3] It is drawing showing the permanent magnet rotation electrical machinery control circuit of one example by this invention.
[Drawing 4] It is drawing showing the principle of operation of the permanent magnet rotation electrical machinery by this invention.
[Description of Notations]
1: Permanent magnet rotation electrical machinery 2: Stator
3: Rotator 4: Stator core
5: Stator winding 6: Permanent magnet
7: Rotor core 8: Shaft
9: Housing 10: and bracket
11: Bearing 12: DC power supply
13: Inverter 14: Control circuit
41: Stator yoke 42: Stator magnetic pole
Hu, Hv, Hw: Magnetic pole position transducer
Tu, Tv, Tw: Switching element
Pt : wiring substrate

[Translation done.]

DRAWINGS

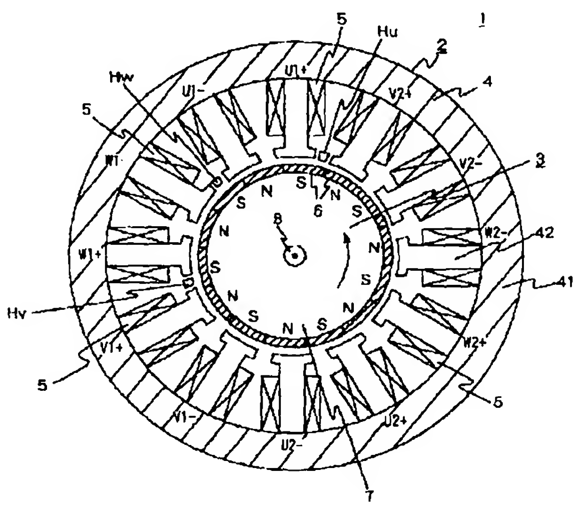
[Drawing 1]

図 1



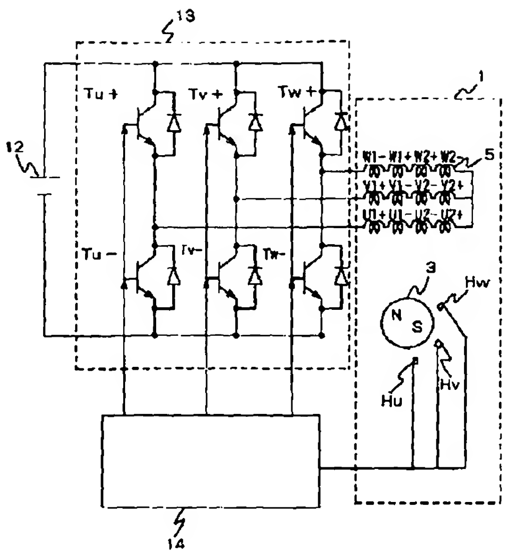
[Drawing 2]

図 2



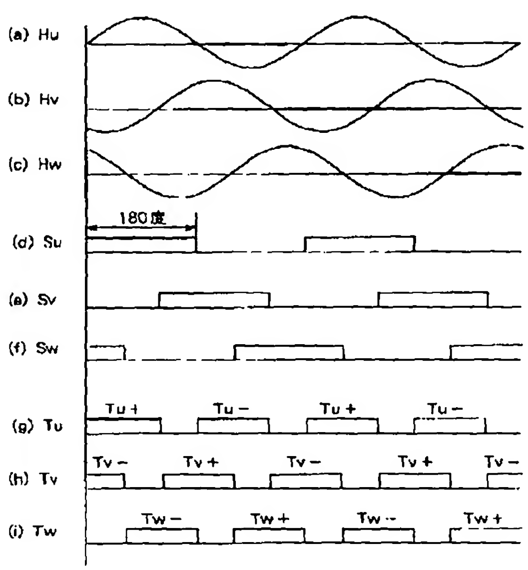
[Drawing 3]

図 3



[Drawing 4]

図 4



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平10－23724

(43)公開日　平成10年(1998) 1月23日

(51)Int.Cl.^{6}	識別記号	庁内整理番号	ＦＩ	技術表示箇所
ＨＯ２Ｋ　29/06			ＨＯ２Ｋ　29/06	Ｚ
1/14			1/14	Ｚ
11/00			ＨＯ２Ｐ　5/41	３０２Ｍ
ＨＯ２Ｐ　5/41	３０２		7/63	３０３Ｖ
7/63	３０３		ＨＯ２Ｋ　11/00	Ｃ

審査請求　未請求　請求項の数３　ＯＬ　（全６頁）

(21)出願番号　特願平8－173403

(22)出願日　平成８年(1996) ７月３日

(71)出願人　000005108
株式会社日立製作所
東京都千代田区神田駿河台四丁目６番地

(71)出願人　000228730
日本サーボ株式会社
東京都千代田区神田美土代町７

(72)発明者　田島　文男
茨城県日立市大みか町七丁目１番１号　株式会社日立製作所日立研究所内

(72)発明者　川又　昭一
茨城県日立市大みか町七丁目１番１号　株式会社日立製作所日立研究所内

(74)代理人　弁理士　高田　幸彦　（外１名）

最終頁に続く

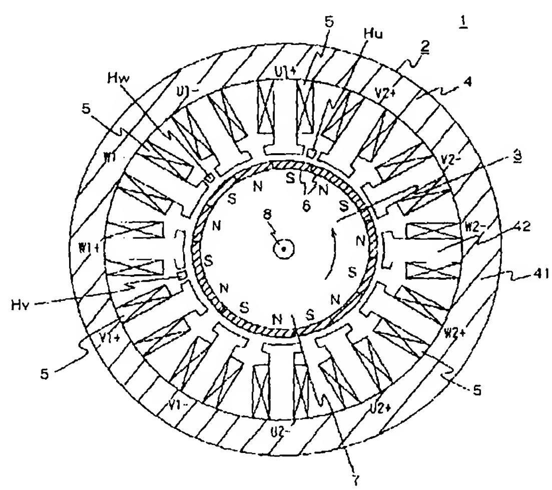
(54)【発明の名称】　永久磁石回転電機

(57)【要約】

【課題】小型軽量で、さらには脈動トルクの小さい永久磁石回転電機を提供する。

【解決手段】回転電機１は、12個の固定子磁極42に集中的に巻回した３相の各固定子巻線５を有する固定子２と、ほぼ等間隔に着磁された14個の永久磁石６を有する回転子３と、隣り合うそれぞれの配置間隔が固定子磁極42の２個分の寸法間隔に設定されている一組の磁極位置検出器Hu,Hv,Hwとを備え、磁極位置検出器Hu,Hv,Hwにて永久磁石６の磁極位置を検出し、該検出磁極位置に応じて各固定子巻線５への通電制御が為されて駆動される。

図　２



【特許請求の範囲】

【請求項1】M個の固定子磁極に集中的に巻回した多相の固定子巻線を有する固定子と、ほぼ等間隔に着磁されたP個の永久磁石極を有する回転子とを備え、かつ永久磁石極数P，固定子磁極数MとをP：M＝６ｎ±２：６ｎ(但し、ｎは２以上の整数)の関係となし、前記永久磁石極の作る磁束から前記回転子の磁極位置を各相の磁極位置検出器にて検出し、該検出磁極位置に応じて前記各相固定子巻線への通電制御がなされて駆動される永久磁石回転電機において、

隣り合う前記各相磁極位置検出器の配置間隔は、１個分の前記固定子磁極の位置間隔の２倍に設定されていることを特徴とする永久磁石回転電機。

【請求項２】請求項１において、前記固定子巻線は、Ｕ相を起点として、Ｕ相はU_{1+},U_{1-},U_{2-},U_{2+}の順に、Ｗ相はU_{1+}から１個分の前記固定子磁極を置いてW_{1-},W_{1+},W_{2+},W_{2-}の順に、Ｖ相は更に１個分の前記固定子磁極を置いてV_{1+},V_{1-},V_{2-},V_{2+}の順に、すべて同方向に結線されたことを特徴とする永久磁石回転電機。

【請求項３】Ｍ個の固定子磁極に集中的に巻回した３相の固定子巻線を有する固定子と、ほぼ等間隔に着磁されたＰ極の永久磁石極を有する回転子とを備え、かつ永久磁石極数Ｐ，固定子磁極数ＭとをＰ：Ｍ＝６ｎ±２：６ｎ(但し、ｎは２以上の整数)の関係とした永久磁石回転電機において、

前記固定子磁極に巻回された固定子巻線を、Ｕ相を起点とし、１個分の固定子磁極を置いてＷ相、さらに１個分の固定子磁極を置いてＶ相の順で同じ方向に、結線したことを特徴とする永久磁石回転電機。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、永久磁石回転電機に係り、特に、トルク脈動の小さい小型軽量の集中巻固定子を有する永久磁石回転電機に関する。

【０００２】

【従来の技術】小型永久磁石電動機は、一般に固定子磁極を有しかつこの磁極に固定子巻線を集中的に配置する構成の集中巻き永久磁石回転電機が使用されてきた。これまで大型回転機の分野まで使用されている分布巻固定子に対して、エンド部が単純な構成となるために電動機の体格を小さくできる、また、コイルの数を少なくできることから構成が単純になる等の利点がある。この種の永久磁石回転電機では永久磁石回転電機の永久磁石の極数Ｐと固定子の磁極数Ｍとの比を２：３とする事が一般であった。しかし、上記方式はコギングトルクが大きい欠点があった。

【０００３】これに対し特開昭６２－１１０４６８号公報(以下、開示例１という)では、永久磁石の極数Ｐと固定子の磁極数ＭとをＰ：Ｍ＝６ｎ±２：６ｎ(ただし、ｎは２以上の整数)とした永久磁石回転電機に関して、コ

ギングトルクの減少及び巻線の利用率が向上し、電動機体格を小さくかつ脈動トルクの少ない電動機を提供できることを開示している。

【０００４】一方、特開昭６２－２２１８５４号(以下、開示例２)では、この種のブラシレスモータを運転させるのに必要な磁極位置検出器(３相の場合は３個使用)の配置を、機械的に１２０度の間隔に配置した例を開示している。いずれも３個の磁極位置は、ブラシレスモータとして運転できるように、各相の磁極位置検出器の電気角を１２０度の間隔に配置する構成である。

【０００５】

【発明が解決しようとする課題】ブラシレスモータを小型軽量、脈動率トルクの低いものにするためには、３個の磁極位置検出器の位置が近く、かつ３個の各相の磁極位置検出器と固定子磁極及びその周囲に巻回された固定子巻線との関係が同一であることが必要である。

【０００６】しかしながら、上記開示例２には、磁極位置検出器の位置が遠く離れる欠点がある。また、各相の磁極位置検出器が電気角１２０度ずつ離れ、かつ最短の位置では各相の磁極位置検出器と固定子磁極及びその周囲に巻回された固定子巻線との関係(例えば、Ｕ相の磁極位置検出器はＵ相の固定子巻線が巻回される固定子磁極の下に配置されるのに対し、Ｖ相の磁極位置検出器もＵ相の固定子巻線が巻回される固定子磁極の下に配置される)が、変わってしまう欠点があった。これは、磁極位置検出器の精度が各相間で大きく異ならしめ、これによって大きな脈動トルクを生ぜしめるからであった。

【０００７】また、開示例１には各突極磁極間の配線構成を工夫し、小型軽量に結び付ける技術については開示されていない。

【０００８】従って、本発明の目的は、上記開示例の課題を解決し、小型軽量の永久磁石回転電機を提供すること、さらには、脈動トルクの小さい且つ小型軽量の永久磁石回転電機を提供するにある。

【０００９】

【課題を解決するための手段】上記目的を達成する本発明による永久磁石回転電機の特徴は、Ｍ個の固定子磁極に集中的に巻回した多相の固定子巻線を有する固定子と、ほぼ等間隔に着磁されたＰ個の永久磁石極を有する回転子とを備え、かつ永久磁石極数Ｐ，固定子磁極数ＭとをＰ：Ｍ＝６ｎ±２：６ｎ(但し、ｎは２以上の整数)の関係となし、前記永久磁石極の作る磁束から前記回転子の磁極位置を各相の磁極位置検出器にて検出し、該検出磁極位置に応じて前記各相固定子巻線への通電制御がなされて駆動される永久磁石回転電機において、隣り合う前記各相磁極位置検出器の配置間隔は、１個分の前記固定子磁極の位置間隔の２倍に設定されている構成にある。

【００１０】また、他の特徴は、Ｍ個の固定子磁極に集中的に巻回した３相の固定子巻線を有する固定子と、ほ

は等間隔に着磁されたP極の永久磁石極を有する回転子とを備え、かつ永久磁石極数P，固定子磁極数Mとを P：M＝6n±2：6n(但しnは2以上の整数)の関係とした永久磁石回転電機において、前記固定子磁極に巻回された固定子巻線を、U相を起点とし、1個分の固定子磁極を置いてW相、さらに1個分の固定子磁極を置いてV相の順で同じ方向に、結線した点にある。

【0011】本発明によれば、各相の磁極位置検出器はそれぞれ120度の電気角で配置されるとともに、固定子の磁極及び巻線から同じ影響を受ける位置にて磁極位置検出ができる。これによって、各磁極位置検出器間の間隔は最短となり小型軽量化が図られるとともに、磁極位置検出が正確となって脈動トルクを小さくすることができる。

【0012】また、固定子巻線の結線長さが各相とも同じになり、小型軽量に結び付けることができる。

【0013】

【発明の実施の形態】以下、本発明の実施の形態について、図面を参照し説明する。図1は、本発明による一実施例の永久磁石回転電機を示す断面図である。本発明に関わる永久磁石回転電機の断面構造を示している。図2は、図1のAA断面を示す図である。図1と図2を同時に参照し構成について説明する。

【0014】図1において、永久磁石回転電機1(以下、回転電機1という)は、固定子2と回転子3とエンドブラケット10と2個のベアリング11と3個の磁極位置検出器(Hu,Hv,Hw)と配線基板Ptとから構成される。固定子2は、ハウジング9と、このハウジング9の内周面に固定された固定子鉄心4と、この固定子鉄心4に巻回された多相の固定子巻線5とからなる。回転子3は、永久磁石6とヨーク7とシャフト8とで構成される。また、シャフト8は、ベアリング11とハウジング9とエンドブラケット10とによって固定子2に回転自在に保持する。そして、一般的にホール素子等で構成される磁極位置検出器は、回転子3の永久磁石6の位置を検出するために、回転電機1の内部に配設された配線基板Ptに装着されている。

【0015】図2において、回転電機1は、主に固定子2と回転子3とからなり、固定子2は固定子鉄心4と固定子巻線5とで構成される。ここで、固定子鉄心4は円環状の固定子ヨーク41と複数個の固定子磁極42とからなり、各固定子磁極42には固定子巻線5が集中的に巻回される構成である。各巻線は空隙面での磁路を共有すること無い構成である。この集中巻構造の固定子は一般の大型機に使用されている分布巻構造の固定子に対して、エンドコイル部の長さを短くすることができるため、回転電機の体格を小さくすることができる利点がある。本実施例の回転電機では、3相で、回転子3の永久磁石極数が14個で、固定子2の固定子磁極数が12個である構成を示した。なお、回転電機が発電機であっても同様な構成にできることは云うまでもないことである。

【0016】そして、図2で示した3相の固定子巻線5としてのU_{1+},U_{1-},U_{2+},U_{2-}と、V_{1+},V_{1-},V_{2+},V_{2-}と、W_{1+},W_{1-},W_{2+},W_{2-}とに対応して、一組の磁極位置検出器Hu,Hv,Hwが配置される。Ptは、それぞれの固定子巻線5のU_{1+},U_{1-},U_{2+},U_{2-}と、V_{1+},V_{1-},V_{2+},V_{2-}と、W_{1+},W_{1-},W_{2+},W_{2-}とを3相結線構成にするとともに、磁極位置検出器Hu，Hv，Hwを固定及び配線する配線基板である。ここで、本実施例における磁極位置検出器Hu，Hv，Hwは、回転子3の永久磁石6の発生する磁束によって、当該永久磁石6の磁極位置を直接検出する構成の磁極位置検出器を対象とする。

【0017】図3は、本発明による一実施例の永久磁石回転電機制御回路を示す図である。図1で示した永久磁石回転電機を駆動する制御回路を示している。図において、直流電源12の電力は、インバータ13を介して回転電機の多相の固定子巻線5に供給される。ここで、インバータ13はTu＋，Tv＋，Tw＋のプラス側のスイッチング素子とTu－，Tv－，Tw－のマイナス側のスイッチング素子とで構成される。更に、回転子3の磁束から磁極位置検出器Hu，Hv，Hwを介して、磁極位置信号を制御回路14内に取り込んで、インバータ13のスイッチング素子Tu＋，Tv＋，Tw＋，Tu－，Tv－，Tw－へのパルス信号を制御する。ここで、固定子磁極42に巻回された固定子巻線5はそれぞれ各相ごとに、図示の順で配線基板Ptを利用して接続され、3相の回転電機1としての結線がなされる。

【0018】図4は、本発明による永久磁石回転電機の動作原理を示す図である。図中、(a)，(b)，(c)は、磁極位置検出器Hu、Hv，Hwの磁極位置信号で、これは回転子3からの磁束を直接検出して出力する。(d)，(e)，(f)のSu，Sv，Swは、上記の磁極位置信号を0点の基準とし比較器を介して出力した信号で、インバータ13のスイッチング素子Tu＋，Tv＋，Tw＋，Tu－，Tv－，Tw－には、それぞれ(g)，(h)，(i)で示すTu，Tv，Tw信号が加えられる。

【0019】なお、必要に応じて、このTu，Tv，Tw信号とPWM(Pulse Width Modulation)信号との論理積(AND)を取った信号が加えられても可である。すなわち、回転電機1は、回転子3の永久磁石6が作る磁束によって当該回転子3(永久磁石6)の磁極位置を磁極位置検出器Hu，Hv，Hwにて検出し、該検出磁極位置に応じて各固定子巻線5への通電切替制御がなされて駆動される。

【0020】ところで、永久磁石回転電機の脈動トルクは、磁極位置検出器Hu，Hv，Hwの磁極位置信号の精度によって大きく依存される。インバータ13のスイッ

チング素子Tu+，Tv+，Tw+，Tu−，Tv−，Tw−には、それぞれ(g)，(h)，(i)で示す信号が加えられ、これは電気角で60度ごとに、図示のように切り替わる。磁極位置検出器の配置が悪く前記磁極位置信号の精度が悪いと、図4(a)，(b)，(c)で示した磁極位置信号が乱れ、例えば、360度の中の一つの区間では50度と短くなり、他の区間では70度と長くなるような区間が生じ、これによって回転電機1の脈動トルク(コギングトルク)も大きくなる。

【0021】そして、従来技術では、磁極位置検出器Huを基準にして、電気角(永久磁石のNS間を360度とする)でそれぞれ120度の間隔で磁極位置検出器Hv，Hwが配置されているものであった。この場合には、磁極位置検出器Hv，Hwは、それぞれ固定子巻線U1+，U1−を巻回した磁極の位置に配置されたことになる。上記構成のそれぞれの磁極位置検出器Hu，Hv，Hwの位置は、磁極位置検出器Huでは固定子磁極42の中間の位置に、それぞれの磁極位置検出器Hv，Hwでは中間の位置からずれた固定子磁極42上の位置となる。

【0022】また、磁極位置検出器Huは制御する固定子巻線U相の位置にあるが、磁極位置検出器Hv，Hwは制御するべき固定子巻線V，W相とは異なる固定子巻線U相の固定子磁極42の位置にある。これらの構成により、磁極位置検出器Hu，Hv，Hwが受ける影響、すなわち、固定子磁極42からの影響及び固定子巻線電流が作る磁界からの影響が、各磁極位置検出器でそれぞれに異なり、前述の磁極位置信号の精度を下げ、脈動トルクを増加させるものであった。

【0023】本発明による実施例では、図2に示すように磁極位置検出器Hu，Hv，Hwの隣り合う配置間隔を1個分の固定子磁極42の位置間隔の2倍に設定するものである。換言すれば、隣り合う各相磁極位置検出器は、固定子磁極の2個分の位置寸法からなる配置間隔を有して配置されているものである。本実施例の配置間隔の構成によれば、各磁極位置検出器Hu，Hv，Hwは、いずれも固定子磁極42の中間の位置(固定子磁極からの影響及び固定子巻線電流が作る磁界からの影響が等価範囲内にある位置)となる。かつ本実施例では、磁極位置検出器Huは、制御するべき固定子巻線U相を巻回保持する固定子磁極42に隣接している位置にあり、磁極位置検出器Hvは固定子巻線V相を持つ固定子磁極42に隣接している位置にあり、磁極位置検出器Hwは固定子巻線W相を持つ固定子磁極42の位置にあるよう配置される。

【0024】さらに換言すれば、制御するべき固定子巻線X_1相に隣接して配置された磁極位置検出器H_1を基準にして、2個分の固定子磁極を置いて固定子巻線X_2相と該固定子巻線X_2相の固定子磁極に隣接して磁極位置検出器H_2を配置し、順次、2個分の固定子磁極を置いて固定子巻線Xn相と該固定子巻線Xn相の固定子磁極に隣接して磁極位置検出器Hnを配置したものであると言える。

【0025】すなわち、磁極位置検出器Hu，Hv，Hwは、共に同じレベル(等価)で固定子磁極42の影響及び巻線電流が作る磁界の影響を受ける。これによって、電気角60度が50度または70度と振れることがなく磁極位置信号の精度が確保されて、脈動トルクの増加を抑えることができる。

【0026】尚、図2の配置において、隣り合う固定子磁極42の電気的な間隔は180度×14極／12=210度となる。従って、磁極位置検出器Huに対して、4個分(図中の①，②，③，④)の固定子磁極42の位置だけ離れている磁極位置検出器Hvは、210度×4−720度=120度となり、120度位相の遅れた位置に配置される。一方、磁極位置検出器Huに対して2個分の固定子磁極42の位置だけ離れている磁極位置検出器Hwは、210度×2−360度=60度となる。磁極位置検出器Hwは、磁極位置検出器Huに対して240度の位相差が必要であるため、磁極位置検出器Hwは図示の位置で電流の方向の反転、及び信号の反転によってさらに180度の位相差を持たせることで、240度の位相差を確保することができる。

【0027】以上を纏めれば、本発明の特徴は、M個の固定子磁極に集中的に巻回した多相の固定子巻線を備えた固定子鉄心を有する集中巻固定子と、ほぼ等間隔に着磁されたP個の永久磁石極を有する永久磁石回転子とを備え、かつ永久磁石極数P，固定子磁極数Mとを、P：M=6n±2：6n(ただし、nは2以上の整数)の関係となし、永久磁石回転子の作る磁束によって当該永久磁石回転子の磁極位置を各相の磁極位置検出器にて検出し、検出した磁極位置に応じて固定子磁極に巻回された各相の固定子巻線への通電を切り替える制御がなされて駆動される永久磁石回転電機において、磁極位置検出器の間隔を固定子磁極位置の間隔の2倍とするにある。

【0028】これによって、各相の磁極位置検出器は、それぞれ固定子磁極及び固定子巻線に対して電気角で120度異なる位置に配置されるとともに、固定子磁極などから各相とも同じ影響を受ける位置にて磁極位置検出ができる。これによって、各相の磁極位置検出器同士の間隔が短くなるとともに、電気的に切り替える間隔が正確となって脈動トルクが小さくなる。すなわち、磁極位置検出器同士の間隔が小さくなることは、制御回路と磁極位置検出器との配線を配線基板P1の小さなスペースで達成できることになり、小型軽量化に結び付けることができる。

【0029】一方、図2，図3に示すように、永久磁石極数P，固定子磁極数MとをP：M=6n±2：6n(但し、nは2以上の整数)とした永久磁石回転電機において固定子磁極42に巻回された固定子巻線5のU相を

起点として、U相はU_{1+},U_{1-},U_{2-},U_{2+}の順に、W相はU_{1+}から1個分の固定子磁極42をおいて W_{1-},W_{1+},W_{2+},W_{2-} の順に、V相はさらに1個分の固定子磁極42をおいて、V_{1+},V_{1-},V_{2-},V_{2+} の順に、すべて同方向(図中では反時計廻り)に結線(配線)することによって、U、V、W相の巻線の引き出し位置及び中性点の接続位置が近くなり、各相の固定子巻線の結線長さが各相とも同じになり、かつ、長さのばらつきも少なくすることに繋がり、小型軽量に結び付けることができる。また、配線基板及び回転電機も小さくすることが可能である。

【0030】以上の構成によって、磁極位置検出器間の配線や固定子巻線の利用率(スペース効率)が良くて小型軽量となる永久磁石回転電機が提供される。さらに、位置検出精度を向上させることによって、脈動トルク(コギングトルク)の小さな永久磁石回転電機が提供される。

【0031】尚、本実施例において、回転型のモータ駆動の適用した場合を例に挙げ説明したが、本発明は、永久磁石電動機方式としてのリニアモータ駆動装置にも適用することができる。また、回転子の位置に対して正弦波状の電流制御を行う制御方式についても、さらに、電流制御をしない方式あるいは120度通電型のブラシレスモータ方式にも適用できることは言うまでもない。

【0032】

【発明の効果】本発明によれば、電気角を120度とし、各磁極位置検出器を当該各磁極位置検出器に対する影響が等価となる位置に配置できるので、電気的に切り＊替える間隔が正確となって脈動トルク(コギングトルク)が小さくなり、かつ各磁極位置検出器同士の間隔が短くなって小型軽量に結び付く効果がある。また、固定子巻線の巻線利用率が向上して小型軽量に繋げることもできる。

【図面の簡単な説明】

【図1】本発明による一実施例の永久磁石回転電機を示す断面図である。

【図2】図1のAA断面を示す図である。本発明の永久磁石回転電機の断面を示す。

【図3】本発明による一実施例の永久磁石回転電機制御回路を示す図である。

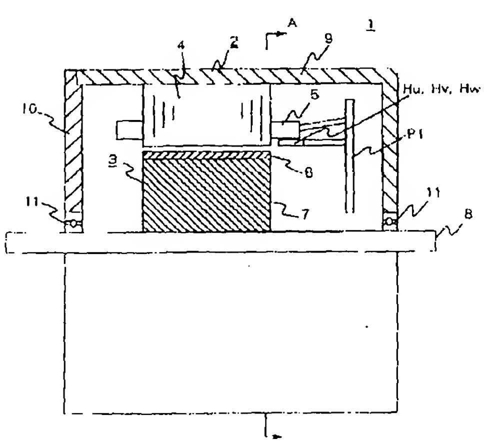
【図4】本発明による永久磁石回転電機の動作原理を示す図である。

【符号の説明】

1：永久磁石回転電機　2：固定子
3：回転子　4：固定子鉄心
5：固定子巻線　6：永久磁石
7：回転子鉄心　8：シャフト
9：ハウジング　10：エンドブラケット
11：ベアリング　12：直流電源
13：インバータ　14：制御回路
41：固定子ヨーク　42：固定子磁極
Hu,Hv,Hw：磁極位置検出器
Tu,Tv,Tw：スイッチング素子
Pt　：配線基板

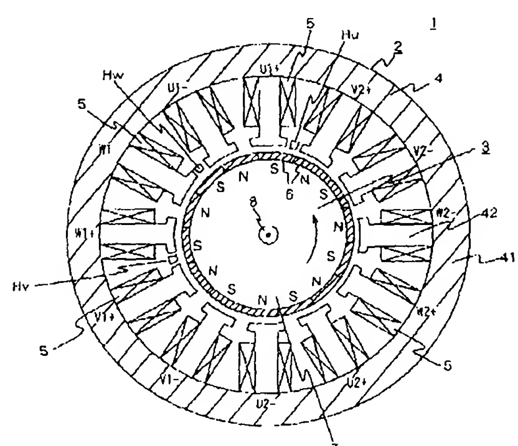
【図1】

図 1



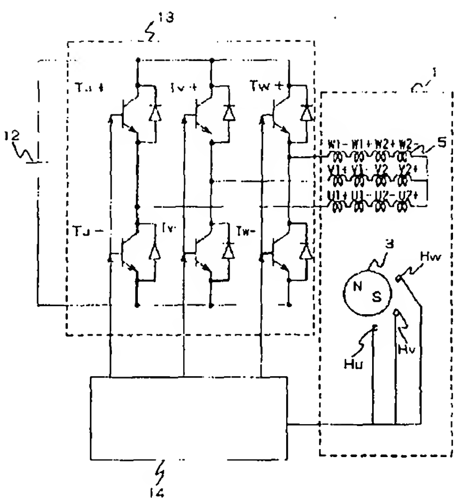
【図2】

図 2



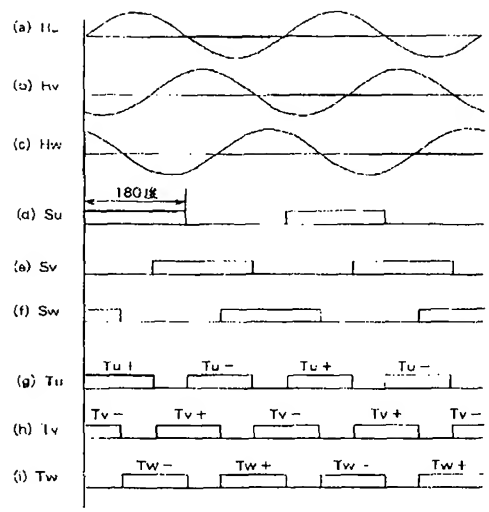
【図3】

図 3



【図4】

図 4



フロントページの続き

(72)発明者 松延 豊
茨城県日立市大みか町七丁目1番1号 株式会社日立製作所日立研究所内

(72)発明者 蛇川 俊美
東京都千代田区神田美土代町7番地 日本サーボ 株式会社内

(72)発明者 大西 和夫
東京都千代田区神田美土代町7番地 日本サーボ 株式会社内